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Africa Research in Sustainable Intensification for the Next Generation - West Africa

Research in sustainable intensification of cereal-based farming systems in the Guinea-Sudan-Savanna of West Africa

**2015-2016 Work plans**

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The Africa Research in Sustainable Intensification for the Next Generation (Africa RISING) program comprises three research-for-development projects supported by the United States Agency for International Development as part of the U.S. government’s Feed the Future initiative.

Through action research and development partnerships, Africa RISING will create opportunities for smallholder farm households to move out of hunger and poverty through sustainably intensified farming systems that improve food, nutrition, and income security, particularly for women and children, and conserve or enhance the natural resource base.

The three projects are led by the International Institute of Tropical Agriculture (in West Africa and East and Southern Africa) and the International Livestock Research Institute (in the Ethiopian Highlands). The International Food Policy Research Institute leads an associated project on monitoring, evaluation and impact assessment.

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| --- | --- | --- | --- | --- |
| **Key partners and their roles** | | | | |
| **Name** | **Accronym** | **Ghana** | **Mali** | **Role/responsibility** |
| Afrique Verte, Mali | 1AMASSA |  | + | On-farm and household nutrition studies with ICRISAT. |
| Association Malienne d’Eveil et de Developpement Durable | 1AMEDD |  | + | On-farm field trials and household nutrition studies with ICRISAT. |
| Agricultural Development & Value Chain Enhancement Program | ADVANCE II | + |  | Assist with market linkages, joint demonstration of technologies |
| Animal Research Institute | ARI | + |  | R4D on livestock production (sheep and goats) with ILRI. |
| Agricultural Technology Transfer Project | ATT | + |  | Assist with the introduction of new labor-saving technologies. |
| The World Vegetable Center | AVRDC | + | + | Lead R4D on vegetable production systems. |
| Community-based Organizations | CBOs | + | + | On-farm implementation of R4D activities. |
| International Center for Tropical Agriculture | CIAT | + |  | Lead R4D on land and soil management. |
| Centre d’Appui a l’ Autopromotion pour le Development | 1CAAD |  | + | On-farm groundnut intensification |
| Le Groupe de Recherches d’Actions et d’Assistance pour le Development Communautaire | 1GRAADECOM |  | + | On-farm groundnut intensification |
| Compagnie Malienne de Developpement des Textiles | CMDT |  | + | On-farm field trials and household nutrition studies. |
| Crops Research Institute | CRI | + |  | Breeder seed of improved cereals and legumes. |
| Food Research Institute | FRI | + |  | Household nutrition. |
| Grains and Legumes Development Board | GLDB | + |  | Production of foundation seeds. |
| Heifer International | 1HI | + |  | On-farm livestock production with IITA. |
| World Agroforestry Center | ICRAF |  | + | Lead R4D on agroforestry systems. |
| International Crops Research Institute for the Semi-arid Tropics | ICRISAT | + | + | Sorghum/millet-groundnut R4D with IITA and SARI. |
| International Food Policy Research Institute | IFPRI | + | + | Lead site selection, baseline survey and M&E |
| Institut d’Economie Rurale | IER |  | + | Socio-economic and on-farm studies with ICRISAT. |
| International Institute of Tropical Agriculture | IITA | + | + | Overall project coordination and R4D research on cereal systems |
| International Livestock Research Institute | ILRI | + | + | Lead R4D on ruminants in Ghana and MRMs governance in Mali. |
| Institute for Scientific and Technological Information | INSTI | + |  | Organize training and publish project document with IITA. |
| International Water Management Institute | IWMI | + |  | Lead R4D on water management. |
| Kwame Nkrumah University of Science and Technology | KNUST | + |  | Graduate student training and R4D on rural pig production. |
| Mouvement Biologique du Mali | 1MOBIOM |  | + | On-farm and household nutrition studies with ICRISAT. |
| Ministry of Food and Agriculture | MoFA | + |  | Scaling-out SI technologies and establishment of R4D platforms. |
| Ministry of Health | MoH | + |  | Household nutrition R4D with UDS and IITA. |
| Post-Harvest Losses Innovation Laboratory | PHL-IL | + |  | Joint studies on comparison of grain storage methods and aflatoxin |
| Savanna Agricultural Research Institute | SARI | + |  | R4D on cereal-legume-veg. systems with IITA, ICRISAT and AVRDC. |
| Seed Producers Association of Ghana | 1SEEDPAG | + |  | Production of certified seeds and training on seed production. |
| Small Scale Irrigation Innovation Laboratory | SSI-IL | + |  | Testing of small-scale irrigation options and model validation |
| Soil Research Institute | SRI | + |  | R4D on integrated soil fertility management with IITA. |
| University for Development Studies | UDS | + |  | Graduate training and R4D on rural poultry and pig production. |
| Wageningen University, The Netherlands | WU | + | + | R4D on farming systems characterization and graduate training. |
| 1Non-governmental organization | | | | |

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**Summary**

The 2014-15 work plans are presented separately for Ghana and Mali to ensure clarity and make the document more reader-friendly. The 2013-14 research year work-packages are mapped under five research themes, namely:

1. Partnerships and socio-economics assessment (Research Theme 1, RT1).

2. Intensification of cereal-legume-vegetable cropping (Research Theme 2, RT2).

3. Intensive livestock and integrated crop-livestock production (Research Theme 3, RT3).

4. Land, soil and water management (Research Theme 4, RT4).

5. Improving nutrition, food storage, value addition and mycotoxin management (Research Theme 5, RT5).

Theme 1 is cross-cutting. Farming systems analysis, gender mainstreaming, capacity building and knowledge exchange and dissemination are embedded in all themes. Linkages between activities under each theme are summarized in separate tables for each country.

In line with the recommendations of the mid-term project review during September-October 2014, R4D and innovation platforms will be established and facilitated in both countries to ensure research is demand driven and to support scaling-up. Additionally, the ‘Technology Park’ approach will be adopted in Mali to ensure integration of activities. Publication of research results and better communication among research teams within and across countries will be a major focus.

**1. Introduction**

**1.1 Africa RISING in West Africa**

The project is being implemented in 25 intervention communities in the three northern regions of Ghana (Fig. 1), and 10 villages in the Bougouni-Yanfolila and Koutiala Districts of the Sikasso Region in southern Mali (Fig. 2). It is intended to result in spillover effects to other similar agro-ecological zones in the two countries and beyond.

The implementation strategy, gender awareness and equity issues, scale of operation, knowledge transfer strategies and research hypotheses which contribute to the overall program research and development outputs have been outlined in the 2013-2014 research year work plans. A brief description of the research themes and research questions to be addressed within the theme is given below was outlined in the 2014/15 research year work plans.

**1.2 Research themes**

The work plans are presented under five research themes, and separately for each country for clarity and to make the document reader friendly. The themes are:

1. Partnerships and socio-economics assessment (Research Theme 1, RT1).

2. Intensification of cereal-legume-vegetable cropping (Research Theme 2, RT2).

3. Intensive livestock and integrated crop-livestock production (Research Theme 3, RT3).

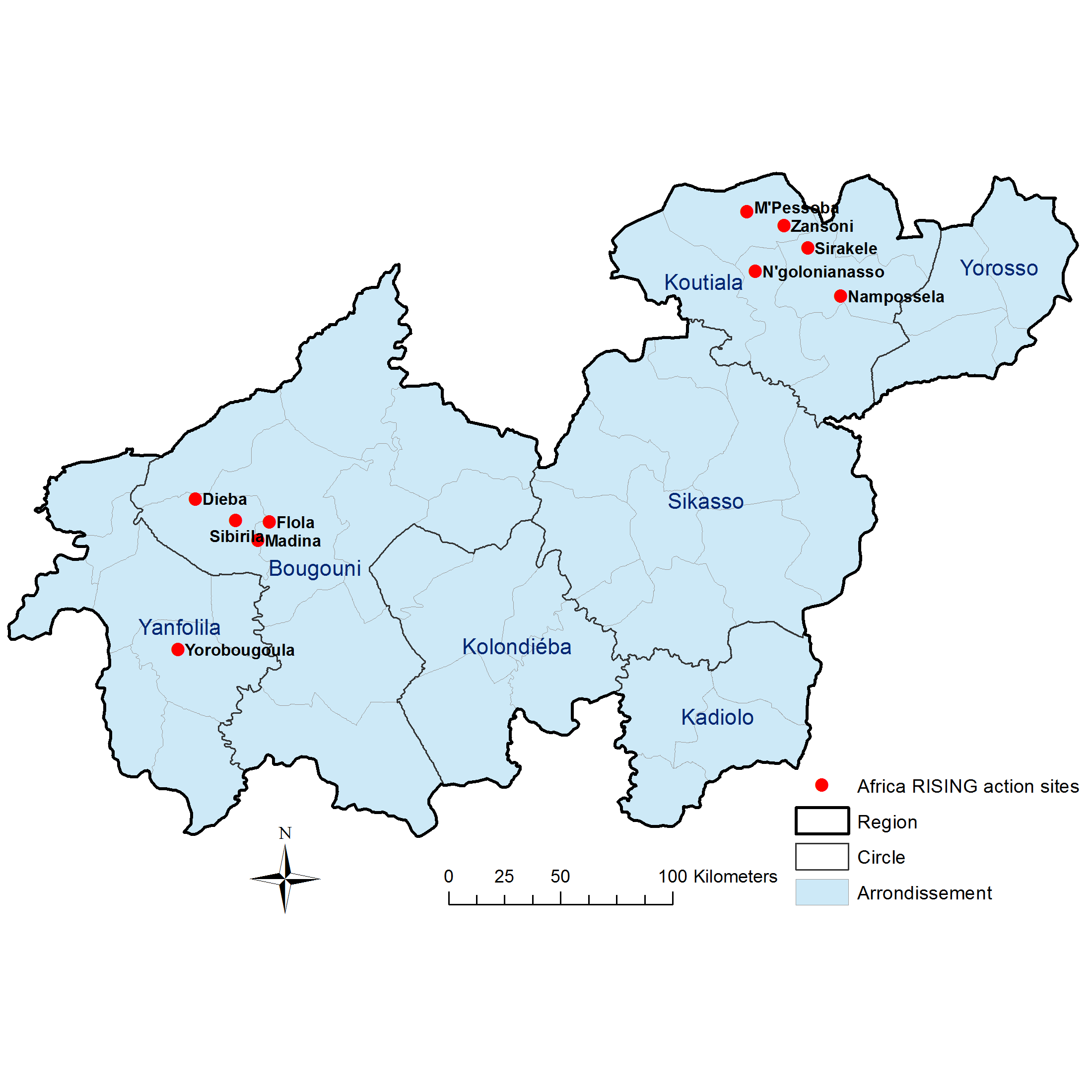
4. Land, soil and water management (Research Theme 4, RT4).

5. Improving nutrition, food storage, value addition and mycotoxin management (Research Theme 5, RT5).

Activities under Theme 1 cut across the other themes. The activities are linked within and across themes to ensure integration. They contribute to the expected outputs of the Africa RISING West Africa project, namely: characterization of the farming systems (Theme 1), increase productivity (Themes 2 and 3), conserve the natural resource base (Theme 4), improve household nutrition and link farmers to markets (Themes 1 and 5), capacity of partners strengthened and knowledge exchange and dissemination improved (Themes 1-5).



Figure 1*.* Africa RISING intervention communities in Ghana.

Figure 2. Africa RISING intervention villages in Mali.

This document presents work plans for the last year of the 5-year project which ends in September 2016. The 2015-16 work plan will therefore focus on data analysis and documentation of results of activities undertaken during the 2012-13, 2013-14 and 2014-15 research years.

**2. Ghana work plan**

**Theme 1: Socio-economics, partnerships and monitoring (RT1-Gh)**

**1. Research team**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Name* | *Institution* | *Degree* | *Research interest* | *Role* |
| Asamoah Larbi | IITA | PhD | Crop-livestock systems | Leader, RT1-Gh-1 |
| Bekele Kuto | IITA | PhD | Agricultural economics | Leader, RT1-Gh-2, 3 |
| Jeroen Groot | WUR | PhD | Farming systems | Leader, RT1-Gh-4 |
| Gundula Fischer | IITA | PhD | Gender/Sociology | Leader, RT1-Gh-3 |
| Mirja Michalscheck | WUR | MSc | Farming systems | PhD student |
| Katrien D | WUR | PhD | Farming systems | RT1-Gh-4 |

|  |  |  |  |
| --- | --- | --- | --- |
| **2. Objectives** | | | |
| 1 | Mobilize communities, revise list of beneficiaries and geo-reference participating households | | |
| 2 | Establish and inaugurate at least 6 district level R4D platforms | | |
| 3 | Conduct a analysis of potential R4D platform actors and their roles | | |
| 4 | Analyze value chains identified by the R4D platforms at the district levels | | |
| 5 | Assess cost and benefit of interventions | | |
| 6 | Create a knowledge sharing and learning framework to facilitate stakeholder interaction | | |
| 7 | Identify and validate different stakeholders and their potential roles in the R4D platforms | | |
| 8 | Assess the adoption of sustainable intensification technologies | | |
|  | | | |
| **3. Activities** | | | |
| **Activity RT1-Gh-1** | | Mobilize communities and facilitate R4D platforms | |
| Lead Scientist(s) | | Asamoah Larbi | Institution: IITA |
| Other scientist(s) | | Mary Asante, Abdul Nurudeen | |
| Consultant | | To be identified | |
| Location(s) | | Intervention communities in Salvelugu, Tolon/Kunbungu, Bongo, Kassena-Nankana, Wa West and Nadowli Districts | |
| **Procedures** | | | |
| *Sub-activity RT1-Gh-1.1: Community mobilization and workshops on 2015 activities* | | | |
| Community consultation initiated in 2015 will continue. Community workshops will be organized to document farmers’ comments on the 2013 participatory trials. During the workshops the possibilities to include more young women and men as Africa RISING beneficieries will be discussed. The 2014 list of interested farmers will be revised (more young mem and women will be considered in the revised list). Households will be tagged or geo-referenced for easy monitoring.  *Sub-activity RT1-Gh-1.2: Facilitation of research for development platforms:* Identification, interviews, validation and recruitment of stakeholders will continue at the district and community levels in all the regions. The input demands during the season will be taken into account in recruiting new stakeholders (for example seed producers and marketers). The R4D platforms in the six districts were launched in 2015. Linkages will be established with the Africa RISING project in the Ethiopian Highlands to assist with the facilitation of the Innovation and R4D platforms. The district level platforms are strategic and broad, but at the community level the IP could follow different value chains or other entry points based on farmers’ interest. | | | |

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| **Deliverables** | | Date (2016) |
| **1** | New stakeholders or actors identified at the community and district levels | June |
| **2** | Facilitation workshop held with Africa RISING Ethipia | May |

|  |  |  |
| --- | --- | --- |
| **Activity RT1-Gh-2** | Economic validation and monitoring adoption of SI options | |
| Lead Scientists(s) | Bekele Kotu | Institution: IITA |
| Other scientist(s) | Stephen Frimpong, Mary Asante, Abdul Nurudeen, David Wawula, Shaibu Bedi, Gundula Fischer, Stephen Frimpong | |
| Location(s) | Intervention communities in Salvelugu, Tolon/Kunbungu, Bongo, Kassena-Nankan, Wa West and Nadowli Districts | |
|  | | |
| **Procedures** | | |
| *Sub-activity RT1-Gh-2.1: Economic validation of selected improved agricultural technologies.* | | |
| The overall objective of this activity is to complement ongoing biophysical studies in the process of maturing agricultural technologies by assessing their economic advantages. It assesses the profitability of Africa RISING (AR) technologies in Ghana. Three major activities will be conducted under this project for this season. These are the following:  1) Contribute to publication of results from completed studies: Many trials are on an advanced stage during this year and hence it is high time to look into the data and produce scientific papers. To this effect, we will work together with the scientists responsible for the trials associated with promising technologies.  2) Data collection will continue for additional season for the remaining technologies under bio-physical evaluation based on the data templates developed for this purpose. The data to be collected from the bio-physical trials will constitute, among others, uses of commercial inputs (fertilizer, chemicals, seeds), labor input, draft-power input (oxen or tractor), land characteristics, outputs (grain and non-grain) and physical materials used. These data will be collected for all treatments to be included in the protocol, including the control. Moreover, secondary sources will be explored to collect data on product prices, input prices, wage rates, land use, features of farm lands, demographic characteristics, and maps of different types and scales  3) For selected technologies which have won farmers’ preferences, additional assessments will be conducted based on participatory approaches which will involve farmers of different categories (i.e. beneficiary farmers, non-beneficiary farmers, women, youth farmers). In addition to profitability, in this case, we will look into how the proposed technologies fit into existing conditions of farmers (such as labor requirements, cash requirements, social acceptability of technologies, and gender roles). This will generate evidence that can be used to scale up/out the technologies. | | |
|  | | |
|  | | |
| *Sub-activity RT1-Gh-2.2: Monitoring the adoption of Africa RISING technologies:* | | |
| The objective of this study is to assess how well Africa RISING technologies are being adopted by the farmers (reasons for adoption and non-adoption). This study will depend mainly on a household survey which involves two rounds of data collection. The first round data collection was conducted in August 2015. Data collection will continue during this plan period. Thereafter, the data will be analysed and a report will be prepared. Scientific papers will also be prepared based on the data. | | |

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| Deliverables | | Date (2016) |
| 1 | Cleaned datasets on adoption of selected AR technologies, uploaded to CKAN | 30 May |
| 2 | Draft report on the status of use of AR technologies | 30 July |
| 3 | MSc thesis on the role of gender in the adoption of sustainable intensification practices in Northern Ghana | 30 Sep |
| 4 | At least two conference papers | 30 Sep |

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| **Activity RT1-Gh-3** | Farming systems analysis and farm re-design | |
| Lead Scientists(s) | Jeroen Groot | Institution: WUR |
| Other scientist(s)  Student(s) | Katrien Descheemaeker, Mirja Michalscheck | |
| Location(s) | Selected communities in the Northern, Upper East and Upper West Regions | |
|  | | |
| **Procedures** | | |
| This activity will identify possibilities to adjust farms and livelihoods of households for sustainable intensification, and to evaluate the impact of implementation on productive, environmental and social performance indicators. It will also inform the households of available options and their impacts, research findings and involve them in research, reflection and learning cycles. This will be closely related to their livelihood strategies.  Collection of additional farm and household information to complement data gathered during rapid characterization and previous community meetings and interviews.  Creating a locally specific ‘basket of technologies’ consisting of potential adjustments to the farms, for instance new crops or animal types, different ways of cultivating crops, managing livestock and manure, surrounding landscape elements, etc. This will be based on entry points previously identified in the participatory community assessments and farming systems analysis.  Participatory and model-based evaluation of the identified options in the basket of technologies. The options will be discussed with farmers, household members, local experts and researchers. They will be evaluated for productive, environmental and social performance indicators in a whole-farm model. In these evaluations there will be emphasis on impacts on household dynamics (including gender balance) and differentiations between various farm/household types and livelihood strategies.  Exploration of tradeoffs and synergies among the productive, environmental and social performance indicators on the basis of the current farm configuration and the available options in the basket of technologies.  All activities will be developed in close consultation and discussion with communities and researchers. There will be explicit attention to the existing heterogeneities in socio-economic and biophysical conditions. | | |

**\*\*Provide deliverables here**

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| --- | --- | --- |
| **Deliverables** | | Date (2016) |
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| **Activity RT1-Gh-4** | Gender analysis of sustainable intensification practices | |
| Lead Scientists(s) | Gundula Fischer | Institution: IITA |
| Other scientist(s) | Bekele Kotu | |
| Location(s) | Selected communities in the Northern, Upper East and Upper West Regions | |
| Consultant | University of Cape Coast, Center of Gender Research, Advocacy and Documentation | |
|  | | |
| **Procedures** | | |
| Since October 2015 a team of gender experts from the University of Cape Coast (in cooperation and under supervision of Dr. Gundula Fischer) has conducted a qualitative gender-focused evaluation of Africa RISING’s interventions in selected communities in the Northern, Upper West and Upper East regions. Core questions of the evaluation were:   1. Evaluation criteria for new agricultural practices: Which criteria do female/male farmers use when evaluating new agricultural practices for suitability? How can gender differences in evaluation criteria be explained? 2. Adoption of Africa RISING practices: Which Africa RISING practices have been/have not been adopted by male/female farmers? Why have female or male farmers adopted/rejected certain practices and what is the relationship with gender dynamics in terms of labour allocation, income distribution, access to resources and to information as well as other key aspects of gender analysis? 3. Adaptation of Africa RISING practices: Have female/male farmers adapted certain Africa RISING practices to make them more suitable for their use? If yes, how have male versus female farmers adapted these practices for their purposes? Why have they adapted them? 4. Access to information and learning: In each community, what are the most important sources of information and learning about agricultural practices? How do female/male farmers have access to information and participate in learning? How can gender differences in access to information and participation be explained?   The research methodology comprised 12 focus group discussions (including a ranking exercise) with farmers in gender-separate groups and key informant interviews with district directors of agriculture, district agricultural extension agents, Africa RISING community facilitators, Africa RISING R4D platform members and traditional leaders (male, female).  Transcriptions and expanded notes of focus groups discussions and key informant interviews as well as a draft report are available.  In 2016 the following steps will be taken to complete the activity:   * Stakeholder validation of the results * Inclusion of results from stakeholder validation into the final report * Publication of final report | | |

|  |  |  |
| --- | --- | --- |
| Deliverables | | Date (2016) |
| 1 | Stakeholder validation completed | May |
| 2 | Submission of final report on gender analysis of sustainable intensification practices | June |
| 3 | Publication of final report on CG space | September |

|  |  |  |
| --- | --- | --- |
| **Activity RT1-Gh-5** | In-country research management | |
| Lead Scientists(s) | Asamoah Larbi | Institution: IITA |
| Other scientist(s) | Bekele Kotu, Mary Asante, Abdul Nurudeen, Stephen Frimpong | |
| Location(s) | Selected communities in the Northern, Upper East and Upper West Regions | |
|  | | |
| **Procedures** | | |
| *Sub-activity RT1-Gh-5.1: Organize regional research team meetings* | | |
| Regional teams meeting will be organized every 4-8 weeks for local and international partners to discuss problems and share lessons. The meeting will be organized on separate days in each region to allow partners working in more than one region to attend*.* | | |
|  | | |
| *Sub-activity RT1-Gh-5.1: Organize travel exchange visits* | | |
| Exchange visits will be organize for farmers, researchers and extension staff at the community, district and regional levels. This will allow knowledge and information exchange and joint learning among partners. | | |

|  |  |  |
| --- | --- | --- |
| Deliverables | | Date (2016) |
| 1 | Regional research team reports completed | Apr, Jun, Aug, Oct |
| 2 | Report on exchange visits at the community, district and regional level | Aug-Sep |

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| --- | --- | --- | --- | --- |
| **4. Expected outcomes** | | Short | Medium | Long |
| 1 | Increased interaction among stakeholders through the R4D platforms | x | x |  |
| 2 | Research institutions use more R4D platforms and less of the linear research-extension approach |  | x | x |
| 3 | Farmers are modifying and adopting technoloties |  | x | x |

|  |  |  |  |
| --- | --- | --- | --- |
| 5. Budget (x 1000 U$) | | | |
| Theme/Activity | Budget Line | IITA | MOFA |
| RT1-Gh-1 | Personnel | 15 | 7 |
|  | Services | 12 | 5 |
|  | Supplies | 8 | 2 |
|  | Travel | 15 | 6 |
|  |  |  |  |
| RT1-Gh-2 | Personnel |  |  |
|  | Services |  |  |
|  | Supplies |  |  |
|  | Travel |  |  |
|  |  |  |  |
| RT1-Gh-3 | Personnel |  |  |
|  | Services |  |  |
|  | Supplies |  |  |
|  | Travel |  |  |
|  |  |  |  |
| RT1-Gh-4 | Personnel |  |  |
|  | Services |  |  |
|  | Supplies |  |  |
|  | Travel |  |  |
|  |  |  |  |
| RT1-Gh-5 | Personnel | 15 |  |
|  | Services | 10 |  |
|  | Supplies | 10 |  |
|  | Travel | 5 |  |
|  |  |  |  |
|  | Total | 90 | 20 |
|  |  |  |  |
|  | Grand total | 110 |  |

**Theme 2: Intensify cropping and integrated crop-livestock systems (RT2-Gh)**

**1. Research team**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Name* | *Institution* | *Degree* | *Research interest* | *Role* |
| Asamoah Larbi | IITA | PhD | Crop-livestock, feeds | Leader, RT2-Gh 1, 2, 3 |
| Saaka Buah | SARI | PhD | Agronomy | Leader, RT2-Gh 2, 3, 4 |
| Jean-Baptiste T | AVRDC | PhD | Vegetable breeding | Leader, RT2-5 |
| Samuel Adjei-Nsiah | IITA | PhD | Agronomy | N2 Africa Country Coordinator |
| Ibrahim Dugje | IITA | PhD | Agronomy | SARD-SC project |
| Atokple IDK | IITA | PhD | Plant Breeding | Cowpea Scaling project |
| Paul Tanzibul | ICRISAT | PhD | Entomology | Groundnut Scaling project |
| Abdul Nurudeen | IITA | PhD | Agronomy | Coordinator, Northern |
| Mary Asante | IITA | MSc | Agronomy | Coordinator, Upper West |
| Theodore Avukpor | KNUST | BSc | Horticulture | MSc student |
| Mohammed Kadir | KNUST | BSc | Horticulture | MSc student |
| Jonathan Naaba | KNUST | BSc | Horticulture | MSc student |
| Iddrisu Bashiru | KNUST | BSc | Horticulture | MSc student |
| Haruna Abudulai | KNUST | BSc | Horticulture | MSc student |
|  | IFDC/ATT  MOFA |  |  |  |

**2. Objectives**

|  |  |
| --- | --- |
| 1 | Disseminate project results through publication of technical and non-technical papers/leaflets |
| 2 | Test and disseminate cereal-legume-vegetable cropping systems to increase productivity per unit area |
| 3 | Develop and test integrated soil fertility management options to improve crop yields |
| 4 | Improve productivity of irrigated and rainfed vegetable production |
| 5 | Train extension agents, farmers and researchers (MSc and PhD students) |

**3. Activities**

|  |  |  |  |
| --- | --- | --- | --- |
| **Activity RT2-Gh-1** | Intensifying integrated cereal-legume-livestock cropping systems | | |
| Lead Scientists(s) | Asamoah Larbi | Institution: IITA | |
| Other scientist(s) | Abdul Nurudeen, Mary Asante, Peter Asongre, Kotu B, S. Frimpong, | | |
| Student(s) | Haruna Abdullai | | |
| Locations(s) | All intervention communities | | |
|  |  | | |
| **Procedures** |  | | |
|  |  | | |
| *Sub-activity RT2-Gh-1.1: Finalizing trials from Phase 1* | | | |
| Selected ‘Mother’ trials initiated in the Technology Parks during the 2013/14 and 2014/15 research years will be continued for the third year in 3-4 communities per region. Results from completed trials will be analyzed and published as posters and/or papers for publication in international peer reviewed journals. | | | |
|  | | | |
| *Sub-activity RT2-Gh-1.2: Productivity of maize-cowpea strip cropping systems:* | | | |
| On-farm trials have shown cereal (maize) and legumes (groundnut, cowpea, soybean) strip-cropping as one of the farmer preferred promising technologies by the Africa RISING project in Ghana. One of the key objectives of strip cropping is to optimize food and feed production without degrading the soil and water resource basse. The quantity and quality of feed and the management of the residues for mulch and feed in the strip cropping systems were not quantified in the previous studies. Also, early-millet-legume strip cropping systems have not been evaluated. The objectives of the current trials are to:   * Out-scale the cereal legume strip-cropping technology (Comment: Not feasible with this type of design).(Possibility of linking with Theme 4 on supplementary irrigation of dual purpose crops) * Evaluate grain and fodder yields and fodder quality from various cereal-legume strip cropping. * Evaluateresidue management for mulch or feed on soil and vegetation properties under strip cropping. * Determine the profitability of various strip cropping systems. | | | |
|  | | | |
| Design and treatments:  A split-plot design with 6-10 replications (farmers will be used) per trial will be established in the NR, UWR and NR. Main plots are two residue management practices and sub-plots are four cropping systems:  Main-plots (residue management)  1. Residue not removed (mulch: soil fertility maintenance)  2. Residuce removed (feeding: livestock)  Sub-plots (cropping systems)  1. Maize alone (M)  2. 1M:1C  3. 2M:2C  4. 2M:4C  Lead farmers with a land area of at least one acre will be identified. Prepare land by preplant application of paraquat to control emerged weeds when rain is fully established. Construct ridges 75 cm apart after land preparation. For the strip cropping, plant cereals and legumes on ridges in the combinations listed above. Participating farmers will be given input (e.g., seeds, fertilizer) and technical support to establish their plots. Sow 2 maize seed per hill at 75 cm by 40 cm. Apply a recommended dose of NPK fertilizer (60-40-40) to both maize and legumes strips in 2 split doses. Apply the first dose of 40-40-40 kg/ha of NPK 15:15:15 at 10-14 days after sowing. Apply the balance of 20 kg N as top dressing at 4 - 5 weeks after sowing. Conduct 2 manual hoe weedings or when necessary. Spray the legumes upto 3 times during the growing season.  Harvest three 2m x 2m plots to estimate total biomass, grain yield and harvest index. After harvest, crop residues from half of the plot will be removed to feed the farmers’ sheep and goats, while residues on the other half will be retained as mulch for soil fertility maintenance.  Data collection: biological (grain and fodder yield, weed biomass and diversity, soil chemical and physical properties) and socio-economic (farmer preferences, labor input, gender distribution of chores)  This activity is implemented in collaboration with the ATT project which will be out-scaling cowpea-maize strip cropping at intervention communities outside the Africa RISING intervention communities. | | | |
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| *Sub-activity RT2-Gh-1.3: Productivity of maize-soybean strip cropping systems:* | | | |
| Design and treatments:  A split-plot design with 6-10 replications (farmers will be used) per trial will be established in the NR and UWR. Main plots are two residue management practices and sub-plots are four cropping systems:  Main-plots (residue management)  1. Residue not removed (mulch: soil fertility maintenance)  2. Residuce removed (feeding: livestock)  Sub-plots (cropping systems)  1. Soybean alone (S)  2. 1M:1S  3. 2M:2S  4. 2M:4S  Lead farmers with a land area of at least one acre will be identified. Prepare land by preplant application of paraquat to control emerged weeds when rain is fully established. Construct ridges 75 cm apart after land preparation. For the strip cropping, plant cereals and legumes on ridges in the combinations listed above. Participating farmers will be given input (e.g., seeds, fertilizer) and technical support to establish their plots. Sow 2 maize seed per hill at 75 cm by 40 cm. Apply a recommended dose of NPK fertilizer (60-40-40) to both maize and legumes strips in 2 split doses. Apply the first dose of 40-40-40 kg/ha of NPK 15:15:15 at 10-14 days after sowing. Apply the balance of 20 kg N as top dressing at 4 - 5 weeks after sowing. Conduct 2 manual hoe weedings or when necessary.  Harvest three 2m x 2m plots to estimate total biomass, grain yield and harvest index. After harvest, crop residues from half of the plot will be removed to feed the farmers’ sheep and goats, while residues on the other half will be retained as mulch for soil fertility maintenance.  Data collection: biological (grain and fodder yield, weed biomass and diversity, soil chemical and physical properties) and socio-economic (farmer preferences, labor input, gender distribution of chores)  This activity is implemented in collaboration with the ATT project which will be out-scaling soybean-maize strip cropping at intervention communities outside the Africa RISING intervention communities. | | | |
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| *Sub-activity RT2-Gh-1.4: Productivity of early millet-groundnut strip cropping systems:* | | | |
| Design and treatments:  A split-plot design with 6-10 replications (farmers will be used) per trial will be established in the NR and UWR. Main plots are two residue management practices and sub-plots are four cropping systems:  Main-plots (residue management)  1. Residue not removed (mulch: soil fertility maintenance)  2. Residuce removed (feeding: livestock)  Sub-plots (cropping systems)  1. Early millet (EM)  2. Groundnut (G)  2. 1EM:1G  3. 2EM:2G  4. 2EM:4SG  Lead farmers with a land area of at least one acre will be identified. Prepare land by preplant application of paraquat to control emerged weeds when rain is fully established. Construct ridges 75 cm apart after land preparation. For the strip cropping, plant cereals and legumes on ridges in the combinations listed above. Participating farmers will be given input (e.g., seeds, fertilizer) and technical support to establish their plots. Sow millet seed at 75 cm by 40 cm. Apply a recommended dose of NPK fertilizer (60-40-40) to both millet and legume strips in 2 split doses. Apply the first dose of 40-40-40 kg/ha of NPK 15:15:15 at 10-14 days after sowing. Apply the balance of 20 kg N as top dressing at 4 - 5 weeks after sowing. Conduct 2 manual hoe weedings or when necessary.  Harvest three 2m x 2m plots to estimate total biomass, grain yield and harvest index. After harvest, crop residues from half of the plot will be removed to feed the farmers’ sheep and goats, while residues on the other half will be retained as mulch for soil fertility maintenance.  Data collectiion: biological (grain and fodder yield, weed biomass and diversity, soil chemical and physical properties) and socio-economic (farmer preferences, labor input, gender distribution of chores) | | | |
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| *Sub-activity RT2-Gh-1.5: Sheep stocking density and agronomic practices effects on productivity* | | |
| The objectives of this trial is to evaluate the impact of integrating sheep and goat management and agronomic practices on grain yield and soil chemical, biological and physical properties.  **Design and treatments**  A split-s-plot design replicated in 3-4 communities in the Upper East region is used. Main-plots are two sheep management practices ( no-corralling, corralling with sheep/goats  1. No corralling  2. Corralling with sheep and goats  Sub- plots are two maize planting densities:  1. Recommended density (66,667 plants/ha).  2. Higher density (133,333 plants/ha).  Sub-plot size will be 4.5m x 5m (6-row plots). Maize will be spaced at 75cm between rows and 40cm within rows.  Data collection: Weed population and density will be evaluated between 2-4 weeks after planting of cereal to determine species diversity and biomass. Grain and fodder yields and soil physical, chemical and biological characteristics will be monitored. | | |
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| *Sub-activity RT2-Gh-1.6: Plant thinning effects on grain and fodder yield* in crop-livestock systems | | |
| Recent studies by SARD-SC has shown that planting maize at double the recommended density and fertilizer rates increases yield and productivity. In an integrated crop-livestock systems, the plants could be thinned and fed to livestock, but the effects of stripping the leaves on the performance of the maize crop and the soil, water and vegetation resources are not well documented. The objective is to explore the possibilities of adjusting the cropping pattern to produce feed from thinning and leaf stripping.  Design and treatment:  A split-plot design, replicated in 3-4 communities per region will be used. Main-plots will be three leaf stripping methods:  1. No thinning (control)  2. Plant thinning at 2 WAP  3. Plant thinning at at 4 WAP.  4. Plant thinning at 6 WAP.  Sub-plots are factorial combinations of twor maize planting density and nitrogen fertilizer application.  1.Recommended density (66,667 plants/ha) with recommended NPK fertilizer rate  2. 50% higher than the recommended density with recommended NPK fertilizer rate  3. 100% higher than the recommended density with recommended NPK fertilizer rate  Data collection: The thinned plants will be used as supplements to tethered piglets and kids. Cost-benefit analysis will be performed. Growth and yield of grain and stover, weed diversity and biomass, quality of the fodder, and weekly live-weight changes in the growing animals fed the fodder will be monitored. Soil moisture and chemical analysis will be monitored. | | |
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| *Sub-activity RT2-Gh-1.7: Cowpea living mulch effects on intensive maize production* | | |
| Soils in the three northern Ghana regions are generally low in fertility, especially organic matter, N, P and K resulting in low grain yields. The living mulch technology has the potential to improve soil physical, chemical and biological status, but there is limited data on its potential in northern Ghana. This study will be conducted in collaboration with the ADVANCE and Scaling Cowpea projects to develop integrated soil fertility management strategies for intensive maize production in the northern and upper west regions.  **Design and treatements**  A split-plot design with cowpea leaving mulch as main-plots and maize planting density as subplots with 4-6 replications.  Main-plots  1. No living mulch  2. Trailing cowpea living mulch  3. Erect cowpea living mulch  Sub-plots  1.Recommended density (66,667 plants/ha) with recommended NPK fertilizer rate  2. 50% higher than the recommended density with recommended NPK fertilizer rate  3. 100% higher than the recommended density with recommended NPK fertilizer rate  Data collection: Growth and biomass yield of maize and cowpea, weed biomass, surface run-off; soil physical (infiltration rate, porosity, temperature, bulk density), chemical (N, P, K), and biological (micro and macro fauna) properties will be recorded. | | |
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| *Sub-activity RT2-Gh-1.8: Organize a short-course on integrated crop-livestock production* | | |
| Integrated crop-livestock systems predominate in the cereal-legume based farming systems in West Africa. Yet most young researchers, especially women have limited skills in the design and implementation of integrated crop-livestock experiments. A short-course will be organized for young research scientists with training in the crop, livestock and biological sciences. Topics to be covered include integrated crop-livestock systems, design of integrated crop-livestock experiments, and analysis and presentation of data from integrated crop-livestock experiments. | | |

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| Deliverables | | Date (2016) |
| 1 | Revised database on completed IITA trials from 2013-2015 | Aug |
| 2 | At least 4-5 mother trials established in 3-4 technology parks in the regions | Jul |
| 3 | At least 3 papers submitted for publication in impact-factored journals | May-Aug |
| 4 | 2-3 integrated crop-livestock trials to address evaluation team recommendation | May-Jul |
| 5 | A short-course on integrated crop-livestock production organized | Jul-Aug |
| 6 | Graduate students (5MSc and 3 PhD) are co-supervised | Jan-Sep |

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| **Activity RT2-Gh-2** | Test and disseminate improved crop varieties and agronomic practices | |
| Lead scientist(s) | Saaka Buah | IITA, SARI |
| Other scientist(s) | Roger Kanton, Peter Asungre, Julius Yilzagla Francis Kusi, Mumuni Abudulai, Nicholas Denwar, James Kombiok, Issah Sugri, Kenneth Opare-Obuobi | |
| Location(s) | Selected intervention communities in the three regions | |
|  | | |
| **Procedures** | | |
| *Sub-activity RT2-Gh-2.1: Establish database and publish results from completed studies* *on CKAN* | | |
| Two years data collected from the following experiments will be used to develop a database. Data will be analyzed and results drafted for publication in peer reviewed journals by the responsible scientists.   1. Responses of extra-early, early and medium maturing maize varieties to fertilizer N in Northern, Upper West and Upper East regions (S.S. Buah, J.M. Kombiok and R.A.L. Kanton) 2. Responses of early and medium maturing soybean to fertilizer and rhizobium inoculation in and Upper West and Northern regions(S.S. Buah and N.N. Denwar) 3. Grain yield of dates of planting and spraying regime on grain and fodder yields of cowpea varieties (Mumuni Abudulai and F. Kusi) 4. Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in soybean-maize rotations in Upper East region (R.A.L. Kanton) 5. Integrated soil fertility management effects on grain and fodder yields and soil chemical and physical properties in cowpea-maize rotations in Upper West region (S.S. Buah) Reducing post-harvest losses in cowpea and maize On-farm trials using 30-50 households per treatment in Northern and Upper East regions (Issah Sugri and M. Abubakari) 6. Potential of round plastic container to reduce post-harvest losses on-farm in Northern and Upper West regions (Issah Sugri and M. Abubakari) 7. Testing of sorghum hybrids trials for identification of yield potential in Upper East region in Northern, Upper West and Upper East regions (K. Opare-Obuobi, S.S. Buah and R.A.L. Kanton) 8. Evaluation and adaptation of millet varieties in Upper East region of Ghana using the Participatory Variety Selection method (Peter A. Asungre) 9. Response of improved rice crop (Gbewaa) to different Nitrogen levels in the Upper East Region (Julius Yirzagla). 10. Participatory evaluation of 8 varieties each of Okra and Roselle using IPM strategies in the Upper East region (Francis Kusi). | | |
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| *Sub-activity RT2-Gh-2.2: Effect of nitrogen fertilizer rates on rice*. | | |
| As with the 2015 cropping season, on-farm trials will be established in Bonia, Nyangua and Samaboligo in the Upper East region (UER) to assess the agronomic and economic benefits of using varying rates of fertilizer N (0, 30, 60, 90 and 120 kg N/ha) on two rice varieties (Gbewaa an farmer variety) during the 2016 cropping season using the Mother and baby variety evaluation approach.Interested households will be selected and given seed and fertilizer. Grain yield and farmer preference will be recorded. | | |
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| *Sub-activity RT2-Gh-2.3: Early millet-cowpea strip cropping intensification among farmers in Upper East region of Ghana.* | | |
| Two improved varieties of cowpea (legume) and one of early millet (cereal) will be used in a strip cropping with the early rains. The cereal and legume will be sown in the following row combinations: 2 cereals: 2 legumes; 3 cereals: 3 legumes; 4 cereals: 4 legumes. Participating farmers will be given input (e.g., seeds, fertilizer) and technical support to establish their plots. A basal dose of 100kg/ha NPK (15:15:15) will be given followed by a selective application of 20kg/ha N only on cereal rows and two sprays of insecticide only on the legumes. RCBD with three or four replications, depending on land availability, will be used with plot size of 6.0m x 5m (30m2) and between rows spacing of 0.75m. The intra-row spacing will be 0.20m for both millet and cowpea. Three seeds of each crop will be sown and thinned to two plants per stand two weeks after sowing. At harvest, crop residues from half of the plot will be removed to feed the farmers’ sheep and goats, while residues on the other half will be retained for soil fertility improvement. Both, biological (grain and fodder yield) and socio-economic (farmer preferred cowpea variety and strip cropping systems, labour input, gender distribution of chores) data will be collected. | | |

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| *Sub-sub-activity RT2-Gh-2.4: Maize-soybean rotation:* |
| An on-station maize-soybean rotation trial to evaluate the response of soybean to organic, mineral and *Rhizobium* inoculants started in 2013 and will continue. Treatments are: 1) soybean (no soil amendment), 2) soybean + inoculant, 3) soybean + inoculant + 60kg/ha P2O5, 4) soybean + inoculant + fertisol, 5) soybean + inoculant + fertisol + 60kg/ha P2O5), 6) soybean + inoculant + 25-60-30kg/ha as N, P2O5, and K2O, 7) continuous maize and 8) continuous soybean. The design is a randomized block with four replications. Plot size will be 4.5m x 5m (6-row plots). Soybean will be spaced 75cm x 5cm and maize at 75cm x40 cm. |
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| *Sub-sub-activity RT2-Gh-2:5 Maize-cowpea rotations* |
| An on-station maize-cowpea rotation trial to evaluate the response of soybean to organic and mineral fertilizer and *Rhizobium* inoculant started in 2013 and will continue. Treatments are: 1) cowpea alone (no soil amendment), 2) cowpea + inoculant, 3) cowpea + inoculant + 60kg/ha P2O5, 4) cowpea + inoculant + fertisol, 5) cowpea + inoculant + fertisol + 60kg/ha P2O5/ha), 6) cowpea + inoculant + 25-60-30kg/ha as N, P2O5, and K2O, 7) continuous maize and 8) continuous cowpea. The design will be a randomized block with four replications. Plot size will be 4.5m x 5m (6-row plots). Cowpea will be spaced 60cm x 10cm and maize at 75cm x 40cm. Plant height, days to flowering, pods per plant, grain and stover yields, harvest index and soil chemical properties, pests and diseases will be monitored in all trials. |

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| **Deliverables** | | Date (2016) |
| **1** | At least 6-8 papers submitted for publication | Dec |
| **2** | Agronomic packages for cereal-legume production identified | Dec |
| **1** | Best agronomic practices and farmer preferred rice variety for rice production | Sep |

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| **Activity RT2-Gh-3** | | Intensification of rainfed and irrigated vegetable production systems | | | |
| Lead Scientist(s) | | Jean-Baptiste Tignegre | | Institution: AVRDC | |
| Other scientist(s) | | Richard Boateng, Alpha Sidy Traore, Larbi Asamoah, A.Nurudeen,,Francis Kusi, IssahSugri, Salim Lamini | | | |
| Student(s) | | Theodore Eyram Avukpor, Mohammed Abdul Kadir, Jonathan Naaba, Iddrisu Bashiru | | | |
| Location(s) | | Three selected communities in each region | | | |
|  | | | | | |
| **Procedures** | | | | | |
| **Activity RT2-Gh-5** | | Intensification ofrainfed and irrigated vegetable production systems | | | |
| Lead Scientist(s) | | Jean-Baptiste Tignegre | | Institution: AVRDC | |
| Other scientist(s) | | Richard Boateng, Alpha Sidy Traore, Larbi Asamoah, A.Nurudeen,,Francis Kusi, IssahSugri, Salim Lamini | | | |
| Student(s) | | Theodore Eyram Avukpor, Mohammed Abdul Kadir, JonathanNaaba,IddrisuBashiru | | | |
| Location(s) | | Three selected communities in each region | | | |
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| **Procedures** | | | | | |
| *Sub-activity RT2-Gh-5.1: Improving productivity of dry season vegetable cropping systems.* The objective of these activities are to (i) determine the optimum water management systems for three crop species through two irrigation techniques and two fertilizer management options, (ii) identify for each vegetable species the best varieties amongst two improved and the best farmers’ variety used as check (adopted or landrace), (iii) determine the interaction between variety and water and soil management systems.The lead and non lead farmers established in selected communities to evaluate and demonstrate production of pure stands (mono-crops) of vegetables under irrigation during the dry season using the ‘mother-baby-trial’ approach. Treatments to be considered will include: vegetable species and/or varieties, agronomic practices (mulch and no-mulch, planting density, fertilizer rates, pest management), and irrigation systems (hand watering from wells, sprinkle and drip irrigation). Six new lead farmers will benefit from infrastructures (fenced and equipped with irrigation facilities).  These investigations are conducted with the participation of farmers to identify scalable technologies. Two sites each in the Upper East regions of Ghana (Niangua and Tekuru).  Three leaer farmers and 15 non leader farmers with available facilities for growing vegetables (wells, fenced areas, vegetable growing experience). In each community, 5 farmers will test same set of fertilizer dose response; 5 other farmers will test same set of tests with two different irrigation options and 5 other farmers will test same set of IPM technologies.  -Fertilizer dose response tests : In each community or site, five farmers will test each two options of fertilizer responses applied to three vegetable species (African eggplants, pepper, okra). Each farmer will be a replication.  -Water management: In each community or site, five farmers will test each two irrigation options applied to three vegetable species (African eggplants, pepper, okra). Each farmer will be a replication.  -Integrated pest Management options: In each community or site, five farmers will test each two IPM options applied to three vegetable species (African eggplants, pepper, okra). Each farmer will be a replication.  Leading farmers: Each of the three leading farmer in each community will test a full option of vegetable technologies:   1. Irrigation option (Drip water and hand carried water can irrigation) 2. 2 Fertilizer dose response (Manure, no manure) 3. 2 IPM options (Neem oil applications & recommended)   *Sub-activity RT2-Gh-5.2:* Promote vegetable seed production at farmer level in the humid season. Twenty lead and non farmers in Northern Ghana will produce vegetable seeds under the supervision of National seed service, IITA and AVRDC. Target crops are Okra, African eggplant and roselle. Each seed farmer will handle 2000m2 (20m x 10m width) for seed production. Best farmer fields will be targeted and serve as model field during practical training sessions. This activity will be conducted in the technology park and at selected farmers’ fields (10 farmers per community).  *Sub-activity RT2-Gh-5.3*: *Hands-on training on best production practices and post-harvest handling.* It is proposed to cluster demonstration and training activities around best practices hubs to be set-up in each of two regions (Northern and Upper East) each connecting to target communities in each of two districts per region. Farmers (households) will be trained, local seed actors/enterprises and extension staff’s knowledge reinforced in intensive vegetable production, integration of vegetables into cereal-legume production systems, community based seed production and storage, post-harvest management. Field days and exchange visits (possibly to neighboring countries) will be used to (a) raise awareness on vegetable-enriched food preparations that preserve or enhance nutritional content, particularly for women and children, (b) raise awareness on exotic and little-known vegetables and legumes and (c), expose farmers to simple postharvest handling options that reduce losses and optimize returns in the market.  Other components of the system: The integration with tree and livestock will be more efficient. This will be implemented for lead farmers at a first stage. Moringa trees and pigeon pea will serve as borders around vegetable fields and between the subtrials (irrigation options and fertilizing options). Livestock (goats) and chicken will be reared nearby the best practice hub and partly fed with vegetable and Moringa residues. A hole of 4m x 3m and 2m deep will be used to keep collected livestock wastes and vegetable residues for producing compost. The compost will be taken to the field and incorporated in the soil.  *Sub-activity* *RT2-Gh-5.4*: *One article on vegetable intercrops in Northern Ghana published in a peer reviewed journal.* The data of the two years-trials (2015 & 2015) on improving productivity of dry season vegetable cropping systems will be analysed; a manuscript will be submitted in a peer reviewed journal for publication    **Activity schedule *RT2-Gh-5***  1-Spread best cropping options of vegetable intercrops  2-Train farmers on for publication of on past trial data | | | | | |
| **Deliverables** | | | | | |

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| 1 | Report of scaling up best vegetablemonocropping and seed production techniques for Upper East, Upper West and Northern Regions Ghana | March 2017 |
| 2 | At least 200 farmers of Upper East, Upper West and Northern Regions of Ghana exposed to vegetable production, protection, irrigation, post harvest managements and seed production techniques. | Mai 2016 |
| 3 | Seed of farmer preferred vegetable varieties produced | Oct 2016 |
| 4 | Published articles in scientific journals about maize-vegetable intercrops in Ghana | Sept 2016 |
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**Expected outcomes**

1-More households are integrating vegetables in their cropping system

2-Farmers are adopting improved agronomic practices

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| **5. Budget (x1000 U$)** | | | | | |
| Theme/Activity | Budget Line | IITA | AVRDC | SARI | MOFA |
| RT2-Gh-1 | Personnel | 125 |  |  |  |
|  | Services | 50 |  |  | 2 |
|  | Supplies | 50 |  |  | 3 |
|  | Travel | 25 |  |  | 10 |
|  |  |  |  |  |  |
| RT2-Gh-2 | Personnel |  |  | 24 |  |
|  | Services |  |  | 12 |  |
|  | Supplies |  |  | 18 |  |
|  | Travel |  |  | 6 |  |
|  |  |  |  |  |  |
| RT2-Gh-3 | Personnel |  | 40 |  |  |
|  | Services |  | 20 |  |  |
|  | Supplies |  | 30 |  |  |
|  | Travel |  | 10 |  |  |
|  |  |  |  |  |  |
|  | Total | 250 | 100 | 60 | 15 |
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|  | Grand total | 425 |  |  |  |

**Theme 3: Intensive livestock production (RT3-Gh)**

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| **1. Research team** |  |  |  |  |
| *Name* | *Institution* | *Degree* | *Research interest* | *Role* |
| Augustine Ayantunde | ILRI | PhD | Feeds, animal husbandry | Leader, RT3-Gh-1 |
| Tunde Amole | ILRI | PhD | Feeds, animal husbandry | RT3-Gh-1 |
| Franklin Avornyo | ARI | PhD | Feeds, animal husbandry | RT3-Gh-1 |
| Asamoah Larbi | IITA | PhD | Crop-livestock production | Leader, RT3-Gh-2-6 |
| Emmanuel Panyan | ARI | PhD | Forage agronomy | RT3-Gh-1 |
| Michael Boateng | KNUST | PhD | Monogastric nutrition | RT3-Gh-2 |
| Terry Ansah | UDS | MSc | Ruminant nutrition | RT3-Gh-4-5 |
| Addah Weseh | UDS | PhD | Feeds, animal husbandry | RT3-Gh-1 |
| Henry Alagma | UDS | BSc | Ruminant nutrition | MSc student |
| Mary Awuni | UDS | BSc | Monogastric nutrition | MSc student |
| Daniel Apalibe | UDS | BSc | Monogastric nutrition | MSc student |
| Goodman Safo | KNUST | MSc | Monogastric nutrition | PhD student |
| Amponsah Bright | KNUST | BSc | Pig production | MSc student |
| Raphael Ayizanga | KNUST | MSc | Animal breeding | PhD student |
| Solomon Kolan | UDS | MSc | Nutrient cycling | PhD student |

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| **2. Objectives** | |
| 1 | Test feed/health options to improve productivity and nutrient cycling in sheep/goat production |
| 3 | Evaluate options to increase productivity of rural poultry production |
| 4 | Evaluate options to improve productivity of rural pig production |
| 5 | Test and disseminate options to increase crop and livestock outputs from fallow lands |
| 6 | Test and disseminate agronomic strategies to optimize feed from cereal-legume cropping systems |
| 7 | Identify high-yield and better quality cereal and legume crop genotypes for food and feed |
| 8 | Improve capacity of extension staff, researchers and farmers in integrated-livestock production |

**3. Activities**

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| **Activity RT3-Gh-1** | Feed and health interventions for improved small ruminant production | |
| Lead Scientist(s) | Augustine Ayantunde | Institution: ILRI |
| Other scientist(s) | Franklin Avornyo, Addah Weseh, Sadat Salifu, Tunde Omole | |
| Graduate students | Solomon Kolan | |
| Location(s) | Botingli, Tibali, Duko (Northern Region), Gia, Nangua (Upper East Region), Guo, Zanko (Upper West Region) | |
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| **Procedures** | | |
| *Sub-activity RT3-Gh-1.1: Feed and health interventions for improved small ruminant production in Ghana* | | |
| It has been demonstrated that simple interventions involving disease control, improved nutrition and better management lead to marked positive effects on small ruminant performance and productivity. Building on activities conducted in 2012 and 2013, feed and health interventions will be carried out in 9 communities involving 3 treatments (Treatment 1 = health intervention: vaccination against PPR (Peste de petits ruminants, goat plague) and Pasteurellosis and deworming using Ivermectin; Treatment 2= health intervention as above and supplementary feeding of balanced rations) and a control (Treatment 3 = no health and no feed intervention). The health interventions will be administered by officials of the Ministry of Food and Agriculture in each region. One village will be selected in each region for each treatment making three villages per region. All small ruminants (sheep and goats) in the six villages (2 villages per region) with health interventions will be vaccinated against PPR and Pasteurellosis, and will be dewormed. The feed interventions will be applied to 10 households in one village per region. Participating farmers will be provided with necessary feed ingredients and will be trained in mixing the ingredients to be used as supplement for their animals. In all the nine villages to be selected for the study, 10 households will be selected for monitoring of their flocks based on their willingness and ownership of at least 6 sheep and 6 goats. All sheep and goats in these households will be ear-tagged and weighed monthly. Manure produced will be collected and weighed monthly. A research assistant will be based in each village for the monitoring of the flock dynamics of the selected households in terms of entries (birth, purchase, animal received as gift or on loan) and exits (death, sales, and slaughter for household consumption, animal given out as gift or loan). MOFA will be responsible for the application of the health intervention including vaccination of the sheep and goats in the 9 intervention communities. The experimental farmers will be trained in mixing the feed rations for their animals. Cost-benefit analyses will be conducted to assess the profitability of feed and health interventions. The 3 treatments explained above will be applied at a village level because of the nature of the treatments (in particular the health intervention). The villages in the same region (3) will be considered as a ‘block’ given that they are close enough and matched enough (on agro-ecological and socio-economic profile). The villages will be RANDOMLY allocated to one of the 3 treatments. Mixed effect models will be used for ANOVA for any response variable with Region effect (2 degrees of freedom), Treatment effect (2 d.f.) and 4 d.f. for the residual and each treatment has 3 replications / villages. Gender differentiation in management of the household sheep and goat flocks will be documented as well as decision making process in animal offtake.  Data collection on feed-health interventions will continue in all the nine intervention communities till August 2016 to complete one year data. The training of the experimental farmers in mixing feed rations will also continue. A manual on improved small ruminant production targeted at smallholder farmers and extension workers will be produced. | | |
|  | | |
| *Sub-activity RT3-Gh-1.2: Building capacity of smallholders in small ruminant production in Ghana:* | | |
| Workshops will be organized to train farmers on many aspects of small ruminant production including disease control, feed formulation, better animal management practices and marketing. For building the capacity of the local communities in disease control, key members of livestock farmers’ associations will be trained in each community by the veterinarians from Ministry of Food and Agriculture in diagnosis of common small ruminant diseases, record keeping and in providing preliminary treatments subject to the national law for the operations of Community-based Animal Health Workers. The training of the Community Animal Health Workers will continue in the intervention communities. The community members to be trained will also be responsible for providing timely situation report to the veterinary services at the district level. Training of farmers has been conducted on conservation of cassava peels, ground nut haulm and rice straw in the 9 intervention communities. Farmers were trained through practical technical demonstrations on methods of ensiling groundnut haulms and cassava peels and urea-treatment of rice straw for feeding ruminants in the dry and cropping seasons in Northern Ghana. In addition to the training of the farmers, it is necessary to assess animal performance as a result of the conservation techniques for improved crop residue management. The plan is to conduct empirical assessment of the effects of the crop residue conservation technologies introduced to the farmers on the growth performance (average daily gain) of their animal. Data to be collected will include nutritional quality of the conserved forages and the effects of supplementing these conserved agro by-products on feed intake and growth performance of sheep and goats. Data will be analyzed with breed, sex and initial weight as random variables in the model. The study will be conducted in two intervention communities per region. These will include Botingle and Tibali (Northern region), Zanko and Guo (Upper West), and Nyangua and Gia (Upper East). A graduate (MSc student) student from University of Development Studies will be put on the project for data collection. Farmers will also be trained in compost making to make better use of the leftovers from animal feeds and household wastes, appropriate storage of crop residues after harvest and manure storage. | | |
|  | | |
| *Sub-activity RT3-Gh-1.3: Nutrient flows in small ruminant production systems in Ghana:* | | |
| Quantifying the nutrient use in smallholder livestock production systems is essential to balancing nutrients supplied in feeds to animals’ requirements, leading to improved livestock production, and consequently whole farm productivity and economic profitability. Also this is important to identify options or strategies for better nutrient management in the systems thereby reducing waste and loss. Eight out of the 20 households to be selected under sub-activity 1.1 will be selected in the three communities in each of the three regions on the criteria of integration of crop and livestock systems, and willingness to participate in a long term study. The households will be monitored over 24 months to address seasonal variations in nutrient use. Feeding practices of the selected households will be monitored as well as manure production of the household flocks. Feed and fecal samples will be collected for laboratory analysis to determine nutrient inflows and outflows in the systems. This activity will be carried out along with the activity on improving small ruminant production. Two years data collection on nutrient flows in small ruminant production systems in the project intervention communities has been completed. The focus of this sub-activity will be on data analysis and preparation of draft manuscript. | | |
|  | | |
| *Sub-activity RT3-Gh-1.4 Fodder production for improved ruminant productivity* | | |
| Fodder species namely *Brachiaria ruziziensis*, *Lablab purpureus* and *Sorghum almum* will be planted in the Technology Park in one community per region to demonstrate the potential of fodder production for improved ruminant production and to build the capacity of the farmers. A plot each measuring 50m2 (10 x 5m) will be established at the Technology Park for each fodder species. Agronomic data such as germination rate, plant height, leaf area index, and total biomass will be collected. Farmers will also be trained on how to plant the fodder species. We would also explore planting some endangered forage species at the Technology Park.  In addition to fodder production, silage making using groundnut haulms and cassava peels will be incorporated into the Technology Park. | | |

|  |  |  |
| --- | --- | --- |
| Deliverables | | Date (2016) |
| 1 | Report and a draft manuscript on improved small ruminant production | Dec |
| 2 | Manual on improved small ruminant production for smallholder farmers and extension workers | Sept |
| 3 | Report on conservation of crop residues for improved small ruminant productivity | Sept |
| 4 | Database on nutiritional quality of feed resources in Northern Ghana | Jun |
| 5. | Report on fodder production | Dec |

|  |  |  |
| --- | --- | --- |
| **Activity RT3-Gh-2** | Evaluate and disseminate options to intensify rural poultry and pig production | |
| Lead Scientist(s) | Herbert Die, Ben Alenyorege | Institution: UDS/KNUST/IITA |
| Other Scientist(s) | Asamoah Larbi, Michael Boateng | |
| Student(s) | Goodman Safo-Kantaka, Daniel Apalibe, Raphael Ayizanga | |
| Location(s) | Tibali, Duko, Botingli, Tibognayili, Cheyohi (Northern Region), Samboligo, Bonia, Nangua(Upper East Region), Zanko, Guo, Passe, Goli, Nato-Douri (Upper West Region) | |
|  | | |
| **Procedures** | | |
| Sub-activity RT3-Gh-2.1: Organize expert consultation on livestock research | | |
| Livestock related activities in the project has been implemented under the leadership of ILRI (sheep and goats), UDS (poultry) and KNUST (pigs).The IITA and USAID commissioned evaluation teams found that livestock research related activities were limited. Both recommended more livestock activities, especially activities related to sheep and goat and poultry production. Over the past 4 years, the Animal Production Division and the Veterinary Services Division of the Ministry of Food and Agriculture, as well as the private sector have played limited roles in the implementation of the livestock activities.  The objective of this activity is to organize a 2-day meeting of the relevant partners to identify researchable livestock activities for joint implementation. | | |
|  | | |
| *Sub-activity RT3-Gh-2.2: Publish survey report as a booklet:* | | |
| A survey of rural poultry production systems in the intervention communities was completed in 2013. The report will be edited and published as a booklet. | | |
|  | | |
| *Sub-activity RT3-Gh-2.3: Develop, evaluate and disseminate improved technologies to intensify poultry production*: | | |
| The survey in 2013 identified lack of enabling institutions and policies, poor market access, lack of improved breeding, inappropriate husbandry (housing, feeding, breeding and health care) practices, as well as lack of information/knowledge as key constraints to rural poultry production. In 2015, farmer participatory research will be conducted to test a combination of housing, feeding and health packages to address the constraints. The exact packages to be tested will be determined from consultations with farmers and the R4D Platforms. Most likely, combinations will be to test the traditional systems of management (control) and improved management (housing, health-care and feeding) using a randomized complete block design with districts as blocks. Data to be collected will include matured live-weight, duration to maturity, mortality, duration of brooding, number of eggs, production costs, income, quantity of manure and profit over a period of 40 days. Trials will be conducted on both domestic chicken and guinea fowls. | | |
|  | | |
| *Sub-activity RT3-Gh-2.4: Develop, evaluate and disseminate technologies to intensify rural pig production:* | | |
| In 2015, farmer participatory approaches will be used to develop, evaluate and disseminate a combination of housing, feeding, breeding and health care options to improve and intensify rural pig production. The exact packages to be tested will be determined from consultations with farmers and the R4D Platforms. These may likely include trials on: comparison of extensive versus intensive management; effect of supplementation in performance of grower and finisher pigs under the free range management system; a survey to document green forage species fed to pigs, and the performance of growing pigs supplemented with different levels of concentrates; development and testing of breeding strategies to reduce inbreeding, meat processing and linking farmers to markets. In all trials, feed intake, body weight gain, feed conversion efficiency, mature live-weight, mortality rate, production costs and net profit will be recorded. The impact of the improved technologies on household income will be assessed. | | |

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| --- | --- | --- | --- | --- |
| **4. Expected outcomes** | | Short | Medium | Long |
| 1 | More households keep their livestock under intensive management | x | x | x |
| 2 | Households have improved manure management |  | x | x |
| 3 | Farmers are adopting lamb fattening to capture niche markets |  | x | x |
| 4 | Village committees are managing fallow lands |  | x | x |
| 5 | Households are producing more feed from cropping systems | x | x |  |
| 6 | National researchers are implementing more integrated crop-livestock activities | x | x | x |
|  |  |  |  |  |

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **5. Budget (x 1000 U$)** | | | | | | | |
| Theme/Activity | Budget Line | IITA | ILRI | ARI | UDS | KNUST | MOFA |
| RT3-Gh-1 | Personnel |  | 72 |  |  |  |  |
|  | Services |  | 36 |  |  |  |  |
|  | Supplies |  | 44 |  |  |  |  |
|  | Travel |  | 18 |  |  |  |  |
|  |  |  |  |  |  |  |  |
| RT3-Gh-2 | Personnel | 4 |  |  | 9 | 10.5 | 10.5 |
|  | Services | 6 |  |  | 6 | 7 | 7 |
|  | Supplies | 2 |  |  | 12 | 14 | 14 |
|  | Travel | 3 |  |  | 3 | 3.5 | 3.5 |
|  |  |  |  |  |  |  |  |
|  | Total | 15 | 170 |  | 30 | 35 | 35 |
|  |  |  |  |  |  |  |  |
|  | Grand total | 285 |  |  |  |  |  |

**Theme 4: Land, soil and water management (RT4-Gh)**

**1. Research team**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| *Name* | *Institution* | *Degree* | *Research interest* | *Role* |
| Davie Kadyampakeni | IWMI | PhD | Soil and water | Leader, RT4-Gh-2 |
| Fred Kizito | CIAT | PhD | Soils, water and landscapes | Leader, RT4-Gh-1 |
| Elias Salifu | CIAT | MSc | Soil water management | MSc, Agronomy |
| Jean-Baptiste Tignegre | AVRDC | PhD | Vegetable improvement | Horticulture |
| Kennedy Nganga | CIAT | BSc | GIS/Remote Sensing | Field excursions and Mapping |
|  |  |  |  |  |
| Pamela Katic | IWMI | PhD | Economics | Market links |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
| Wilson Agyare | KNUST | PhD | Soil, crops, agronomy | Trials on RT4-GH1-4 |
| Francis Tetteh | SRI | PhD | Soil, crops, agronomy | Soil science |
| Emmanuel Panyan | ARI | PhD | Soil, crops, agronomy | Agronomic expertise |
| Rockyfeller Achuliwor | KNUST | BSc | Soil and Water Management | Graduate Student |
| Asamoah Larbi | IITA | PhD | Crops, livestock | Leader, RT4-Gh-3 |

**2. Objectives**

The main objective in this work-package is to improve soil, land and water management practices to improve crop-livestock production systems of northern Ghana. Specifically, this component will:

|  |  |
| --- | --- |
| 1 | Test small-scale irrigation technologies for dry season vegetable production |
| 2 | Test water management practices to improve productivity in rainfed crop-livestock systems |
| 3 | Prepare and disseminate knowledge materials to end users |
| 4 | Evaluate options to improve land and soil management practices within farming systems |
| 5 | Draft and submit 2-3 journal papers |
| 6 | Monitor, implement and demonstrate best-bet on-farm water, soil and land conservation interventions for improved water, soil and nutrient retention. |
| 7 | Provide farmer recommendations and conduct trade-off analysis coupled with scenario generation for soil and land restoration strategies that highlight associated economics of land degradation and restoration management. |

**3. Activities**

|  |  |  |
| --- | --- | --- |
| **Activity RT4-Gh-1** | Testing small-scale irrigation options for dry season vegetable[[1]](#footnote-1) production | |
| Lead Scientist(s) | Davie Kadyampakeni | Institution: IWMI |
| Other Scientist(s) | Pamela Katic | |
| Location(s) | Tekuru, Nyangua in the Upper East Regions | |
| Other Partners | Asamoah Larbi, Jean-Baptiste Tignegre, Fred Kizito, Wilson Agyare | |
|  | | |
| **Procedures** | | |
| Irrigation management is critical for sustainable crop production particularly in the dry season. The following sub-activities will be implemented and will be linked to the ILSSI project in one of the selected sites.  *Sub-activity RT4-Gh-1.1.* Q*uantifying of surface and groundwater resources* : Quantifying of surface and groundwater resources will be conducted for watersheds where AR target communities are located in order to assess feasibility of dry season vegetable production and supplementary irrigation of cereal-legume rainfed crops..  *Sub-activity**RT4-Gh-1.2. Participatory evaluation of water lifting and water delivery methods for vegetable production:* Various water lifting and conveyance technologies will be compared with regards to water productivity, labor and cost requirements for the dry season vegetable production. The following water lifting and delivery technologies will be implemented: (In progress)   * Water lifting technologies: i) motorized pumps, ii)Solar pump iii) water cans/buckets * Water application methods: i) drip, ii) furrow, iii) overhead tank with a hose, iv) bucket irrigation and v) sprinkler irrigation.   *Sub-activity RT4-Gh-1.3. Assessment of irrigation frequency and amount using different irrigation scheduling methods:* A simple tool (sensor-based) will be tested to assist farmers in the irrigation scheduling of vegetables. The tool indicates when the root-zone is dry and when it becomes saturated during irrigation. The water productivity and overall irrigation application rates using the sensors will be compared against: i) a fixed irrigation schedule and ii) the farmers’ normal practice. The assessment on farmers’ fields will include appropriate nutrient and pest management practices and it will provide an opportunity for farmers to compare the tested irrigation scheduling methods with respect to water, labor and time savings. This will also provide the framework for farmers to judiciously optimize irrigation management in water scarce environments. | | |

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|  | Deliverables | Date |
| 1 | Journal manuscript on watershed characterization drafted and submitted | August 2016 |
| 2 | Conduct farmer exchange visit on improved watershed management and irrigation systems. | May 2016 |
| 3 | Upload collected watershed characterization data on CKAN | Oct. 2016 |

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| **Activity RT4-Gh-2** | Exploring potential supplementary irrigation in rainfed crop-livestock production system | |
| Lead scientist(s) | Davie Kadyampakeni | Institution: IWMI |
| Other scientist(s) | Pamela Katic | |
| Location(s) | Nyangua | |
| Other Partners | Asamoah Larbi;Emmanuel Panyan, Fred Kizito, Wilson Agyare | |
|  |  | |
| **Procedures** | | |
| The rainfed crop-livestock production system requires demonstration of effective water management interventions to enhance productivity. In particular, crop production is often affected by rainfall irregularities and is actually scarce during the dry season. This activity component will explore with farmers, the potential for adopting irrigated dual purpose crop production in Ghana. The following sub-activities will be implemented.  Sub-activity RT4-Gh-2.1: *Dry spell analysis of selected catchments in Northern and Upper East Ghana:* This subactivity will include the analysis of long-term rainfall trends on data collected for the past 30 to 50 years in cereal (maize, sorghum and millet) and legume (cowpea, soy bean) cropping system. The dry spell analyses, a follow-up to biophysical watershed characterization done in 2015/2016 will be supported with simulations of cropping scenarios under supplementary irrigated or entirely rainfed conditions to provide guidelines for supplementary irrigation.  *Sub-activity RT4-Gh-2.2: Piloting supplementary irrigation for* dual purpose*crop production:* Under supplementary irrigation dual purpose crops will be produced specifically maize and cowpea, soybean or groundnut.   |  |  |  | | --- | --- | --- | |  | Deliverables | Date | | 1 | Deploying of dual purpose production plots and farmer training in Upper East Ghana | Jul-Aug 2016 | | 2 | Journal manuscript on dryspell analysis for informed decision making on farming cultural practices and supplementary irrigation options | Oct. 2016 | | 3 | Relevant data to CKAN | Oct. 2016 | | 4 | Technical report and guidelines on irrigated dual purpose production drafted | Dec. 2016 | | 5 | Journal manuscript on supplementary irrigation potential for dual purpose drop production in Northern Ghana | Feb. 2017 | |  |  |  |  |  |  |  | | --- | --- | --- | | **Activity RT4-Gh-3** | Piloting improved combinations of soil and land management strategies on-farm | | | Lead Scientist(s) | Fred Kizito | Institution: CIAT | | Other scientist(s) | Davie Kadyampakeni, Wilson Agyare, Francis Tetteh, Kennedy Nganga | | | Location (s) | Bonia, Nyangua and Gia (Upper East Region); Northern Region | | |  | | | | **Procedures** | | | | In order to provide viable interventions and recommendations, we propose piloting of on-farm trials to address erosion prevalence and land degradation that will in turn increase crop productivity through three sub-activities outlined below:  *Sub-activity GT4-3.1: Re-inforce and maintain established on-farm land and soil conservation structures*: This will entail maintenance of established tied-ridges, cover crops, and contour cropping compared against farmer practices.  *Sub-activity GT4-3.2: Monitor soil losses, nutrient movements and soil moisture variation*. To provide evidence for sub-activity 1.1;   * Soil losses will be monitored by a modified version of runoff soil loss detectors that captures 75% of the plot runoff zone; the dimensions of the runoff detectors are 1 m x 0.15 m x 0.15 m. * Nutrient dynamics will be monitored using suction lysimeters which will be held at a tension of 70 cbars and installed at varying depths along the profiles of interest in order to ascertain fate and transport as well as verify what percentage is captured within the crop root zone; * Soil moisture will provide vital links to both soil and nutrient losses. Soil moisture will be monitored using a diviner probe (Sentenk Inc.) to depths of 1.0 m at 10 cm increments within the profile. Access tubes for moisture measurement with the diviner probe will be installed in the center position of the target plots. | | |   *Sub-activity GT4-3.3: Evaluate effectiveness of land and soil conservation structures towards mitigating soil losses, nutrient losses and soil moisture conservation*. This will entail conducting a detailed analysis of the spatial and temporal trends of the data collected through monitoring in sub-activity 3.2. Essentially, the assessment will include evaluation of soil conservation practices (both structural and vegetative) towards environmental integrity (allowing moisture infiltration, reducing erosion and nutrient losses).   |  |  |  | | --- | --- | --- | | Deliverables | | Date | | 1 | Planning with partners, field layouts implemented and instrumentation deployed; On-farm land and soil conservation structures re-inforced and maintained | May-Aug. 2016 | | 2 | Technical Report on effectiveness of land and soil conservation structures towards mitigating soil losses, nutrient losses and soil moisture conservation | Sept-Oct 2016 | | 3 | Upload soil losses, nutrient dynamics and moisture variation data on CKAN | Oct. 2016 | | 4 | Regional online climatic data analysis from on-farm weather stations in Upper East, Northern Ghana and Upper West Regions rolled out and availed to partners and other AR Themes for decision making | Nov. 2016 | | | |

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| **Activity RT4-Gh-4** | Farmer recommendations, tradeoff analysis and scenario generation for land restoration strategies | |
| Lead Scientist(s) | Fred Kizito | Institution: CIAT |
| Other scientist(s) | Wilson Agyare, Francis Tetteh, Kennedy Nganga | |
| Location (s) | Bonia, Nyangua and Gia (Upper East Region); Northern Region | |
|  | | |
| **Procedures** | | |
| *Sub-activity GT4-4.1: Economics of farm productivity in the context of soil conservation measures*: This will involve: conducting economics of farm productivity that incorporate labor and level of effort for land and soil conservation measures; quantifying losses associated for the lack of action (would use on-farm counter-factual results); and quantify (monetary and non-monetary) the benefits of action associated with interventions. Collecting data on farmers’ allocation of time to daily farming activities will be linked to mapping of farmers’ lands including details of farming practices and land use that was conducted in an earlier study over the same sites.  *Sub-activity GT4-4.2: Policy and farmer recommendations, tradeoff analysis and scenario generation*. This consists of: simple farmer-tailored recommendations that communicate key recommendations; a web-based interface for the research community, policy makers and implementing NGOs on key findings; and overall synthesis for trade-off matrix and scenario generation based on above sub-bullets.  A key component of this sub-activity will include an exchange learning field visit of lead farmers in both the Northern Region and Upper East Region to demonstration farms on soil and water conservation in another region of Ghana at the Center for No-Till Agriculture.  Sub-activities 4.1 and 4.2 will document the biophysical (soil properties and crop yield) and socioeconomic (income and other quality of life indicators) benefits that farmers achieve through soil and water conservation practices. The findings will provide insight on policies that will further encourage farmer adoption of soil and water conservation practices that can then be further passed on to the Ghanaian government.   |  |  |  | | --- | --- | --- | | Deliverables | | Date | | 1 | Training of lead farmers and agricultural extension agents conducted with an exchange field visit for soil and water conservation | May 2016 | | 2 | Farmer recommendations for soil and water conservation drafted | September 2016 | | 3 | Journal manuscript on tradeoff analysis and scenario generation completed | August 2016 | | 4 | Technical Report on progress submitted to Donor | October, 2016 | | | |

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| --- | --- | --- | --- | --- |
| **4. Expected outcomes** | | Short | Medium | Long |
| 1 | Households are adopting improved water, soil and land management |  | x | x |
| 2 | More households are harvesting water for dry season vegetable production | x | x | x |
| 3 | Improved water management and water savings in dry season vegetable irrigation in smallholder production systems |  | x | x |
| 4 | Improved yields in vegetable production system and increased household nutrition |  | x | x |
| 5 | Increased fodder production for better livestock nutrition |  | x | x |
| 6 | Increased acreage of farm lands under improved soil and water conservation practices |  | x | x |

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| **5. Theme 4 2016 Budget (US$)** | | | |  |
|  | Budget Line | CIAT |  | IWMI |
| Activity 1 | Personnel | 30,000 |  | 50000 |
|  | Services | 2,000 |  | 21000 |
|  | Supplies | 6,300 |  | 10,000 |
|  | Travel | 2,800 |  | 2,000 |
|  | **Total** | **41,100** |  | **86,000** |
|  |  |  |  |  |
| Activity 2 | Personnel | 24,000 |  | 17,000 |
|  | Services | 3,500 |  | 7,000 |
|  | Supplies | 2,000 |  | 6,000 |
|  | Travel | 1,800 |  | 5,000 |
|  | **Total** | **31,300** |  | **39,000** |
|  |  |  |  |  |
| Activity 3 | Personnel | 28,000 |  |  |
|  | Services | 4,000 |  |  |
|  | Supplies | 2,400 |  |  |
|  | Travel | 3,200 |  |  |
|  | **Total** | **27,600** |  |  |
|  | **Grand Total** | **110,000** |  | **125,000** |

**Note: Please consider that no changes were made on the Post harvest component since they were not part of this meeting; need to share with them to revise accordingly**

**Theme 5: Nutrition, food storage, value addition and mycotoxin management (RT5-Gh)**

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| --- | --- | --- | --- | --- |
| **1. Research team** |  |  |  |  |
| Name | Institution | Degree | Research interest | Role |
| Mahama Saaka | UDS | PhD | Public health nutrition | Leader, RT5-Gh-1 |
| Sofo Mutaru | GHS | MSc | Community nutrition | RT5-Gh-1 |
| Jacob Mahama | GHS | MPh | Public nutrition | RT5-Gh-1 |
| Bridget Parwar | WIAD | MSc | Community nutrition | RT5-Gh-1 |
| Chrisantus Daari | GHS | MSc | Community nutrition | RT5-Gh-1 |
| Gloria Kobati | GHS | MSc | Community nutrition | RT5-Gh-1 |
| Adebayo Abbas | IITA | PhD | Postharvest management | Leader, RT5-Gh-2 |
| Asamoah Larbi | IITA | PhD | Crop-livestock systems | Coordination |
| Ranajit Bandyopadhyay | IITA | PhD | Mycotoxin management | Guidance |
| Abuelgasim Elzein | IITA | PhD | Mycotoxin management | Leader, RT5-Gh-4 |
| Alejandro Ortega-Beltran | IITA | PhD | Mycotoxin management | Co-leader, RT5-Gh-4 |
| George Opit | PHL-IL | PhD | Pest Management | PHL-ILs contact |
| Francis Appiah | KNUST | PhD | Food technology | Leader, RT5-Gh-3 |
| Daniel Agbetiameh | KNUST | MSC | Mycotoxin management | PhD student |
| Richard T. Awuah | KNUST | PhD | Mycotoxin management | RT5-Gh-4 |
| Jojo Baidu Forson | Bioversity | PhD | Agricultural economics | Leader, RT5-Gh-6 |

**2. Objectives**

|  |  |
| --- | --- |
| 1 | Compare the nutritional and health outcomes of focused behavior change communication (BCC) combined with nutrition-sensitive agriculture interventions with only agricultural interventions among children and pregnant mothers |
| 2 | Conduct training for women groups on positive deviance to improve household nutrition and health of the target groups |
|  | Establish a linkage between aflatoxin biocontrol using aflasafe, nutrition, post harvest and livestock teams to harmonize awareness creation campaigns to improve knowledge on better household nutrition, improved crop storage practices, and the menace of aflatoxin to human health, animal productivity and trade. |
| 4 | Improve mothers’ knowledge in nutrition, hygiene and feeding practices |
| 6 | Determine the nutritional and anti-nutritional characteristics of cereal and legume-based food products as consumed in the target communities |
| 7 | Introduce and test the acceptability of nutritionally enhanced crops and vegetables |
| 8 | Conduct studies on effect of traditional processing methods on nutrient retention and bioavailability |
| 9 | Introduce, evaluate and promote technologies to reduce post-harvest losses in stored cereal and legume grains at the household and community levels |
| 10 | Introduce, evaluate and promote labor saving devices for value additions/processing |
| 11 | Test the efficacy of biopesticides Aflasafe GH01 and Aflasafe GH02 to reduce aflatoxin levels under farm conditions and initiate pilot-scale scaling up of the biopesticides |
| 12 | Conduct training of trainers workshops on improved soybean and cowpea processing, product development and food hygiene/safety |
| 13 | Build capacity individual (MSc and PhD) and institutional capacity for research on post-harvest losses and value addition |
| 14 | Establish dietary diversity metrics and methods for Africa RISING |

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| **3. Activities** | | |
| **Activity RT5-Gh-1** | Improve household nutrition | |
| Lead Scientists(s) | Mahama Saaka | Institution(s): UDS |
| Other Scientist(s) | Chrisantus Daari, Gloria Kobati, Sofo Mutaru, Bridget Parwar, Mary Paula Kogana | |
| Consultant | To be identified | |
| Location(s) | Intervention communities in the three regions | |
|  | | |
| **Procedures** | | |
|  | | |
| *Sub-activity RT5-Gh-1: Ientify children at risk of malnutrition early enough for counseling and rehabilitation*  Trained Community Health Workers (CHWs) will conduct monthly community based growth monitoring and promotion (GMP) linked with home visits for children aged 6-36 months. GMP provides counseling to the mothers regarding the nutritional status of their children as indicated by the growth chart. The CHW may also do home visits if the child’s growth chart shows no progress or if he/she misses a weighing session. | | |
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| *Sub-activity RT50Gh-1.3: Conduct support visits to programme communities* | | |
| Monthly facilitative support visits will be made to growth monitoring and mother support groups meeting sessions by sub-district community health workers. This will provide an opportunity for the supervisors to observe trained CHWs working with mothers/caregivers, compare their performance to standards that are outlined in a supervision checklist, and provide constructive feedback on both the strong points and any difficulties the CHWs have experienced. Supervisors/mentors will then be able to judge the effectiveness of the initial training and provide on-the spot refresher training as needed. Supervision of CHW will be carried out by Community Health Nurses in the sub-districts.  There will also be quarterly review of health and nutrition-related activities at the community level whereby feedback will be given to the workers and stake-holders. | | |
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| *Sub-activity RT5-Gh-1.3:* Improve mothers’ knowledge in nutrition, hygiene and feeding practices | | |
| BCC sessions will be held at the community level to improve nutrition and hygiene practices. Cooking demonstration sessions at the community level will be organized to train women on the preparation of appropriate recipes using locally available food types.  Formation/re-activation of mother to mother support groups which should meet monthly in each community to share key messages including the importance of diversifying diets, nutrition during pregnancy, early and exclusive breastfeeding, the appropriate quantity and quality of complementary foods, and preventive healthcare services, such as immunizations, and antenatal care. | | |
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| *Sub-activity RT5-Gh-1.4:* Conduct trainings for women groups on positive deviance to improve household nutrition and health of the target groups. | | |
| About 200 pregnant women and nursing mothers with children under 36 months in each region will be trained in positive deviance approach to adopt appropriate nutrition practices. Positive Deviance Hearth Nutrition Model will be applied at household level to disseminate information regarding child feeding practices, promoting the practice of key beneficial maternal & child nutrition messages including the importance of diversifying diets, nutrition during pregnancy, early and exclusive breastfeeding, the appropriate quantity and quality of complementary foods, and preventive healthcare services, such as antenatal care behaviors. Contents of curriculum include group formation, communication skills and monitoring & evaluation. | | |
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| *Sub-activity RT5-Gh-1.5: Evaluate strategies for improving household nutrition:* | | |
| Establish links with crops, water management and livestock components of the project for the production of nutritious foods foods for households  Endline evaluation of ongoing community intervention will be carried out in 50 intervention and comparison communities. The assessment will compare the impact of providing BCC messages to individual mothers via peer counselors and providing such messages through Positive Deviance (PD) approach.  The interventions that are being implemented are:   * Legumes, Vegetables and Livestock + BCC delivered through community GMP * Legumes, Vegetables and Livestock + BCC delivered through Positive Deviance (PD) approach.   The comparison communities have received no interventions from IITA. | | |

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| Deliverables | | Date (2017) |
| 1 | 80% coverage of children aged 0-36 months attending monthly community based growth monitoring promotion (GMP) session | Feb, 2017 |
| 2 | 800 women trained in positive deviance approach to nutrition delivery | Feb, 2017 |
| 3 | 40% of the households engaged in the production of poultry and small ruminants through the supply of improved seeds, breeds and training delivered to farm families. | Feb, 2017 |
| 4 | Endline evaluation report on strategies to improve household nutrition | Feb 2017 |

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| **Activity RT5-Gh-2** | Reducing postharvest losses in stored grains of cereals and legumes | |
| Lead scientists(s) | Abass Adebayo, Asamoah Larbi | Institution: IITA, ATT |
| Other scientist(s) | Issa Sugri, George Opti, Bekele Kuto, Samuel Obeng-Ofori, , Musa Taylor | |
| Student (s) | To be identified | |
| Location(s) | Tibali, Duko, Tibognayili, Cheyohi (Northern Region); Samboligo, Bonia, Nangua (Upper East Region), Zanko, Guo, Passe, Goli, Nato-Douri (Upper West Region) | |
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| **Procedures** | | |
| On-farm trials will be conducted to evaluate, adapt and disseminate storage technologies to reduce post-harvest losses in stored grain, especially maize, groundnut and cowpea.  The activities will be undertaken in collaboration with the Post-harvest Losses Innovation Laboratory, which will provide expertise in entomology, facilitate pilot-testing of a low-cost moisture meter, monitoring aflatoxin levels and research in drying technologies. A letter of intent will be signed with GrainPro to evaluate, adapt and demonstrate some of their products in graduate student’s dissertation research work.  Most of the on-farm studies will use a randomized complete block design (RCBD) with communities as blocks and households as replicates, and farmers’ current practices as controls. The trials will be conducted in 6 communities with 10-20 households per treatment based on the size of the community. The trials will be conducted over 12-18 months. Data to be collected every two months will include: pest infestation, volume per weight loss, quality losses (physical, biochemical, nutritional, economic), aflatoxin levels and farmers’ perceptions. | | |
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| *Sub-activity RT5-Gh-2.1:* Evaluate and demonstrate small-scale machinery | | |
| This activity will be implemented in collaboration with the Agricultural Technology Transfer project. Small-scale, labour-saving machinery (shellers, planters, tillers, fodder choppers) will be evaluated against farmers’ current practice as control. Most of the machinery will be obtained from the ATT project and compared at Africa RISING communities in the three regions with the farming communities. Male and female farmers’ preferences, labor and time saved by the introduced machinery will be recorded. Cost-benefit ratio of using the machinery will be estimated. | | |
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| *Sub-activity RT5-Gh-2.2: On-farm comparison of storage technologies to prevent stored-product insect infestation of maize:* | | |
| Treatments will include:  1. Actellic Super-treated maize in 50kg polyethylene bags (poly sacks)  2. Untreated maize in 50kg polypropylene (PP) bags and  3. Untreated maize in 50kg deltamethrin (DM) incorporated polypropylene VF ZeroFly bags  4. Untreated maize in 50kg Super Grain Bags (GrainPro)  5. Untreated maize in 50kg PICS bags | | |
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| *Sub-sub-activity RT5-Gh-2.3: Effect of jute and PIC sacks and grain protectants on maize and cowpea losses on-farm*: | | |
| Treatments:  1. Jute sack  2. PICS bag  3. GS4 sacks  4. Jute sack + protectant  5. PICS bag + protectant  6. GS4 sack + protectant  For each treatment, 50kg of maize and 50kg of cowpea will be stored in jute, PICS and GS4 sacks with or without grain protectants. Two commonly used grain protectants, Actellic Super EC and phostoxin were applied at the recommended rates. Actellic Super EC is a food-grade chemical containing 80g/l pirimiphos-methyl and 15g/l permethrin as emulsifiable concentrate. The application dose provided by the manufacturer is 300ml in 15l of water for 20 maxi bags of maize. Post-harvest losses will be monitored over a period of 12 months. | | |
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| *Sub-sub-activity RT5-Gh-2.4: Evaluate, adapt and disseminate GrainPro products*: | | |
| Sign a letter of intent with GrainPro representative in West Africa to evaluate and demonstrate some of their products. GrainPro will provide the products which will be used for on-farm demonstrations in the Africa RISING intervention communities to compare the new products with farmers’ practices. Potential products to be evaluated include:  1. Super Grain Bags (SGB IV-R)  2. Collapsible Dryer Case  3. Silbags | | |

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| Deliverables | | Date (2016) |
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| **Activity RT5-Gh-3** | **Biological control of aflatoxins in maize and groundnut with aflasafe GH01** | |
| Lead scientist(s) | Ranajit Bandyopadhyay | Institution: IITA |
| Other scientist(s) | Abuelgasim Elzein, Alejandro Ortega-Beltran | |
| Consultant | Richard Awuah | |
| Student(s) | Daniel Agbetiameh | |
| Location(s) | Tibali, Duko, Tibognayili, Cheyohi, (Northern Region), Nangua, (Upper East Region), Zanko, Guo, Passe, Goli, Nato-Douri (Upper West Region) | |
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| **Procedures** | | |
| *Sub-activity RT5-Gh-3.1:* *Intensive laboratory analyses of nearly 1,000* samples *collected from the comprehensive field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02, conducted across different environments in Ghana in 2015* | | |
| Carry out microbiology analysis (strain isolation, mutant development, complementation) in IITA-Ibadan of the collected soil samples from both treated and control fields before Aflasafe application and three months after harvest, to determine the native population structure of *Aspergillus* in these fields and carryover potential of the atoxigenic strains constituting the two Aflasafe products.  Carry out microbiology (strain isolation, mutant development, complementation) and chemical (aflatoxin extraction and quantification) analyses in IITA-Ibadan to generate efficacy data for the collected grains samples from both treated and control fields after application, for evaluating field efficacy and recovery atoxigenic strain consituents of the applied products (Aflasafe GH01 & Aflasafe GH02).  These set of efficacy data are a prerequisite for the preparation of a registration dossier and will provide proof and evidence to facilitate registration of the products and future commercialization. | | |
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| *Sub-activity RT5-Gh-3.2: Sensitization and training workshops.* | | |
| The scope of public sensitization on aflatoxin and its management through novel biocontrol technology will be continued and broadened. For increasing awareness and enhancing participation on aflatoxin biocontrol activities, selected health personel from the Ghana Health Service and Agricultural Extension Agents (AEAs) will be trained on the health impacts of consuming aflatoxin contaminated food. Further, AEAs and lead farmers in focued communities will be trained on aflatoxin biocontrol using aflasafe, its mode of application, crop and soil sampling techninques. These trainers (health personnel, AEAs and lead farmers) will in turn sensitize and train households in their focused communities. Target category of household participants will include farmers, aggregators, millers, poultry farmers, and traders. Stakeholder trainings and sensitizations will be frequently monitored to ensure effective delivery.  The planned awareness and training activities of this work package will be linked to those led by the other activities under this research theme.  We will also try to coordinate and link this activity with ICRISAT work on aflatoxin management in groundnut in Africa RISING project. | | |
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| *Sub-activity RT5-Gh-3.3: Large-scale field efficacy validation trials for pre-registration of Aflasafe GH01 and Aflasafe GH02 as biopesticides:* | | |
| Following the sensitization and training workshops, farmers and/or farmer associations and sites for on-farm efficacy evaluation of the aflasafe biocontrol agents will be identified and selected from the Africa RISING focus communities. A total of 240 fields will be selected, comprising 60 each treated and untreated (control) maize fields (i.e. 20 fields per region) and 60 treated and untreated (control) groundnut fields (i.e. 20 fields per region). Field sizes will range between 0.3 ha and 1 ha and separated from control fields by at least 25 m. Each field will be considered a replicate.  Three tons of quality Aflasafe products (one and half ton each of Aflasafe GH01 and Aflasafe GH02) will be produced by IITA Aflasafe Manufacturing Plant, in Ibadan, Nigeria, for these large-scale field efficacy validation trials in Northern Ghana.  The trials will be conducted on crops grown by farmers as per their normal agronomic practices. Farmers will be sensitized and trained on application time and method of the aflasafe biocontrol products.  Field soil samples will be collected prior to application of the aflasafe biocontrol products to measure the native population structure of *A. flavus* and after harvesting to measure the changes in the *Aspergillus* community structure due to biocontrol product application. During the 2016/17 project year (from Oct 2016 onwards), sample collection of maize and groundnut grains and soil after application will be carried out for microbial and chemical (aflatoxin) analyses to generate efficacy data. Large data sets will be generated from the extensive analyses of samples collected from the planned comprehensive field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02. These field efficacy data will be used for the preparation of dossier to facilitate registration of the Aflasafe products as biopesticides. | | |
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| *Sub-activity RT5-Gh-3.4:* *Carry-over of atoxigenic strains of Aflasafe products from one season to the next and its cumulative impact on aflatoxin reduction 1−3 years after Aflasafe application*. | | |
| In this activity, the frequency of application of Aflasafe GH01 or Aflasafe GH02 over 3 consecutive growing seasons in the Northern Region in farmers’ fields will be continued for the second year in 2016. One hundred and twenty (120) maize fields comprising 60 fields per Aflasafe product selected in the previous year will be used for this trial. These will be sub-divided into 6 treatments of 10 fields each. In treatment 1, fields will be treated in alternate years with Aflasafe GH01 or Aflasafe GH02 within the period of the experiment. In treatment 2, fields will be inoculated consecutively in all three growing seasons. Fields in treatment 3 will be inoculated only in the first and second growing season while in treatment 4 inoculation will be carried out only in the first growing season. Fields in treatment 5 will be inoculated only in the third year while fields in treatment 6 will serve as control with none of the fields inoculated throughout the study period.  Field soil samples and crop (grain) samples will be collected in each growing season for microbial and chemical analyses.  In addition to the 240 fields in the Africa RISING areas in northern Ghana mentioned above (funded by Africa RISING), efficacy trials will also be conducted in the Middle Belt (funded by another complementary project – the Meridian/PACA/BMGF regional biocontrol development). The country-wide efficacy trials are required to determine the efficacy of biocontrol in several agro-ecozones. | | |
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| *Sub-activity RT5-Gh-3.5:* *Scaling out of Aflasafe technology innovation (expansion) in partnership with the GIZ project in maize value chain and SPRING/Ghana (a USAID funded nutrition project) in Ghana.* | | |
| Partnership was established and meeting was held with the team leader of the Green Innovation Centre for Agriculture and Food Sector – Ghana, a Ghanaian-German programme assisted by the German Government via the Deutsche Geselischaft für Internationale Zusammenarbeit (GIZ), aiming at promoting the use of Aflasafe technologly to reduce aflatoxin contamination in the maize value chain in GIZ project areas. Outcomes of these meetings and contacts are i) common interest and partnership between IITA and GIZ project was established, ii) through this partnership, Aflasafe production and dispatch of Aflasafe products to small- holder farmers in the Brong Ahafo, Ashanti, Volta and Central regions in Ghana was planned to treat approximately 1,500 ha in 2016, and iii) sensitization and awareness creation workshops, and stakeholder trainings will be conducted on the prevalence of aflatoxin contamination in maize; its health and economic importance to the citizenry; management and the use of aflasafe as a mitigation strategy; and potential opportunities to market grains harvested from aflasafe-treated fields, to increase awareness and enhancing participation on using aflasafe technology for aflatoxin control in maize.    In collaboration with SPRING/Ghana, Aflasafe technology will complement with other activities (initiatives) for improving household nutrition and value addition in northern Ghana. Linkages and contacts have been made with SPRING/Ghana on use (scaling up) of aflasafe in communities of SPRING/Ghana. Common interest and partnership between IITA and SPRING/Ghana project was established. Aflasafe will be introduced in 150 farmer field school demonstration plots (61 ha) for the management of aflatoxin, across 15 districts in the Northern and Upper East regions in 2016. SPRING/Ghana aims to improving household nutrition in two regions—Northern Region and Upper East Region. Unlike the GIZ project, SPRING/Ghana expects IITA to pay for the product. It is estimated that 7,500 farmers will benefit from the activities conducted in the field school demonstration plots . | | |
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| *Sub-activity RT5-Gh-3.6:* *Combined pre- and post- harvest innovations*: | | |
| In partnership with the Feed the Future Reduction in Post-Harvest Losses Innovation Lab, options for minimizing postharvest losses and aflatoxin contamination in maize and groundnut through combining pre-harvest intervention using aflasafe biocontrol and postharvest innovation will be identified and evaluated. Aflatoxin biocontrolactivities will be linked with ICRISAT’s work on aflatoxin resistant groundnut varieties and improved cultural practices to reduce aflatoxin accumulation. The pre-harvest activities will be linked with **Activity RT5-Gh-2** ‘*Reducing postharvest losses in stored grains of cereals and legumes’* led by Drs. Abass Adebayo, and Asamoah Larbi, and will beundertaken in collaboration with the Post-harvest Losses Innovation Laboratory, which will provide expertise in monitoring aflatoxin levels and research in drying technologies. The introduction of drying technologies will give farmers the opportunity to preserve the quality of their commodities by immediately drying grains to the appropriate moisture content. While aflasafe minimizes pre-harvest aflatoxin contamination in maize and groundnut, effective drying with this innovation will help preserve grain quality and further minimize post-harvest crop losses. | | |
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| *Sub-activity RT5-Gh-3.7: Inspection of Aflasafe efficacy trials in farmers fields by Environmental Protection Agency (EPA) for its registration in Ghana* | | |
| Active partnership with Ghanaian regulatory authorities such as the EPA and PPRSD of MOFA has been built and will be further strengthened in 2016, to facilitate promotion and registration of the Aflasafe products in the future and strengthen national advocacy coalitions for supporting the process of product registration.  Linkages have been made with EPA who will be involved in monitoring Aflasafe product testing, aiming at promoting benefit of Aflasafe technology with regulators towards registration in Ghana; this is a prerequisite for product registration. A consultation visit and meeting was made and held with the Director of EPA by Dr. Ranajit Bandyopadhyay and Dr. Richard Awuah, to facilitate the inspection and registration  process of technology. During this visit in Ghana, we had the opportunity to i) introduce in details Aflasafe biocontrol technology and at the same time receiving EPA technical guidelines and requirements for field efficacy inspection and registration, ii) setup an action plan for the inspection of Aflasafe field efficacy trials in 2016, and iii) obtain permission from the regulatory body EPA to treat 4,000 ha with Aflasafe products in 2016. We will organize visits of EPA and PPRSD officials to a few efficacy trial sites to enable these officials to understand the nature and application of the technology. | | |

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| Deliverables | | Date (2016) |
| 1 | Recovery of aflasafe biocontrol strains and aflatoxin analyses completed for 1,000 samples obtained from field efficacy evaluation trials of Aflasafe GH01 and Aflasafe GH02 conducted across Ghana in 2015. | June |
| 2 | Up to 50 trainers (30 health personnel and 20 AEAs & Field technicians including lead farmers) trained on the health impacts of aflatoxins and its management who in turn train over 950 farmers with at least 40% women farmers and trainers | July |
| 3 | Efficacy validation trials of Aflasafe GH01 and Aflasafe GH02 in more than 200 fields. | July – November |
| 4 | Carry-over trials of atoxigenic strains of Aflasafe products after Aflasafe application in 120 fields. | August – November |
| 5 | Aflasafe technology scaled up in partnership with SPRING/Ghana (a USAID funded nutrition project) and with GIC (a GIZ funded project in Ghana. Data on number of households applying aflasafe products will be collected. | July- October |
| 6 | Benefits of combined pre- and post- harvest innovations determined. | October |
| 7 | Environmental Protection Agency (EPA) officials will inspect Aflasafe efficacy trials in farmers fields for its registration in Ghana. | July – November |
| 8 | At least one manuscript drafted and submitted: Biocontrol of aflatoxins in maize and groundnut with aflasafe GH01 and aflasafe GH02: two biopesticides developed for Ghana (Journal: Plant Disease). | December |

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| **4. Expected outcomes** | | 2014 | 2015 | 2016 |
| 1 | Households are adopting behaviors to improve dietary diversity | x | x | x |
| 2 | Caregivers/women apply their nutritional skills in food preparation | x | x | x |
| 3 | Households adapt technologies that reduce post-harvest losses |  | x | x |
| 4 | Extension officers have included aflatoxin management in their messages |  | x | x |
| 5 | Households have adopted measures to reduce aflatoxin in maize and groundnut |  | x | x |

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| **5. Budget (x1000 U$)** | | | | |
| Theme/Activity | Budget Line | IITA | UDS | MOFA |
| RT5-Gh-1 | Personnel |  | 8 | 13 |
|  | Services |  | 4 | 7 |
|  | Supplies |  | 3 | 10 |
|  | Travel |  | 5 | 5 |
|  |  |  |  |  |
| RT5-Gh-2 | Personnel | 28 |  |  |
|  | Services | 14 |  |  |
|  | Supplies | 31 |  |  |
|  | Travel | 7 |  |  |
|  |  |  |  |  |
| RT5-Gh-3 | Personnel | 38 |  |  |
|  | Services | 14 |  |  |
|  | Supplies | 61 |  |  |
|  | Travel | 7 |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  | Total |  |  |  |
|  |  |  |  |  |
|  | Grand total |  |  |  |

1. The vegetables will be selected in consultation with farmers, IITA, AVRDC and NGO working in the area. [↑](#footnote-ref-1)